

Performance Verification of Ship Ballast Water Treatment Technologies

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EPA Science Forum

Healthy Communities and Ecosystems

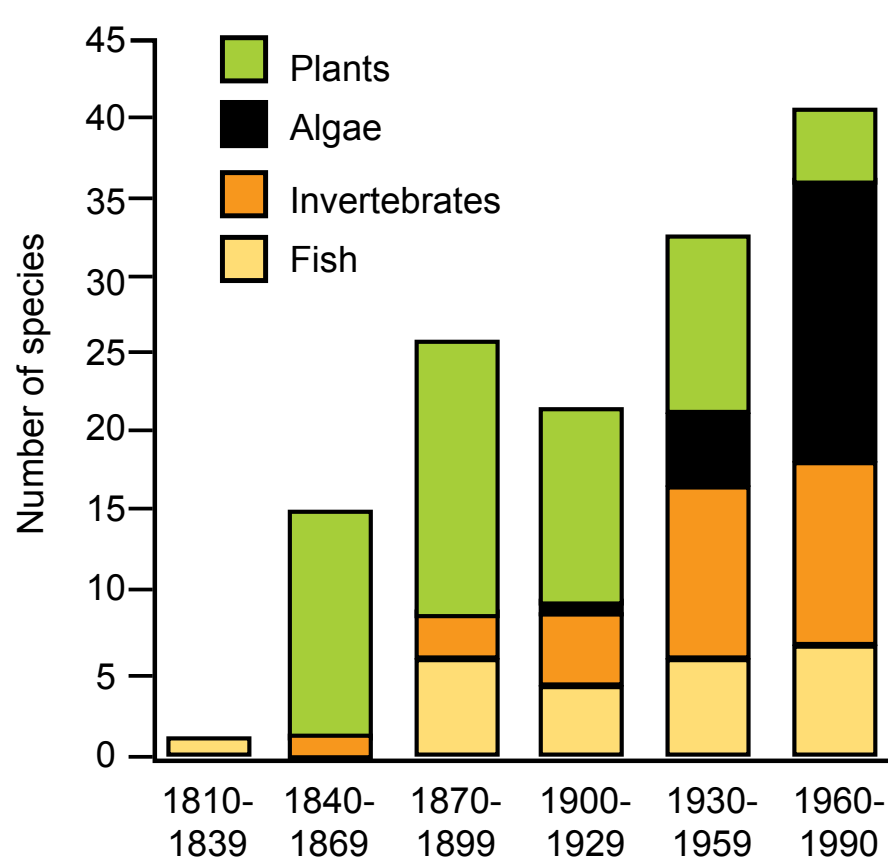
Abstract

Ships use ballast water (BW) to provide stability during a voyage and during loading and unloading operations. Water is taken on at one port when cargo is unloaded and usually discharged at another port when the ship receives cargo. Because organisms ranging in size from viruses and bacteria to fish living in the surrounding water or sediments are taken on board with BW, there is a potential for the introduction of non-native organisms - called bioinvasers, alien species or exotic species - into the port of discharge. A number of methods to prevent these unwanted introductions are available; however, no single BW management technique has been able to remove all organisms or all types of organisms from ballast tanks. A combination of different methods may prove to be more effective than one method alone; however, little research has been conducted into this possibility. It is difficult to implement treatments because ship owners are reluctant to install technology that is expensive, unreliable or time consuming.

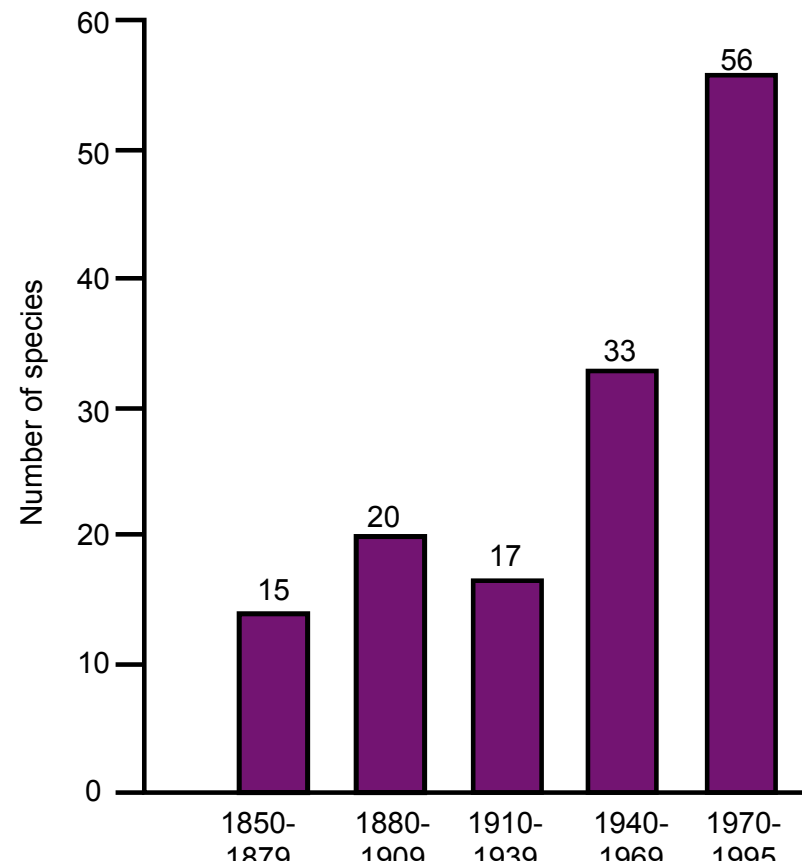
Nonindigenous Species Problem

It has been estimated that foreign species are introduced to new environments somewhere in the world every nine weeks. The introduction of these non-native organisms can cause destructive and irreversible changes to ecosystems and ecosystem functions, including serious declines and total extinctions of native species. They also can cause adverse effects on physical infrastructure and human health. In the U.S. approximately 10-20 trillion gal of BW are discharged annually. The economic impacts associated with this has been estimated to be approximately \$135 billion/yr.

Great Lakes



San Francisco Bay Region



How Do They Get Here ?

Thousands of nonindigenous species are transported in ships ballast water from one port and released into other ports. BW is required by ships worldwide to:

- Maintain waterline & stability during loading & unloading operations
- Maintain stability at sea
- Aid propulsion & maneuverability
- Reduce stress on hull

Increased Importance of Ships as Transporters of Nonindigenous Species

- Ship size, number of ships, transit speeds, voyage frequency
- Combination leads to increase in number, type, vigor of organisms introduced with BW



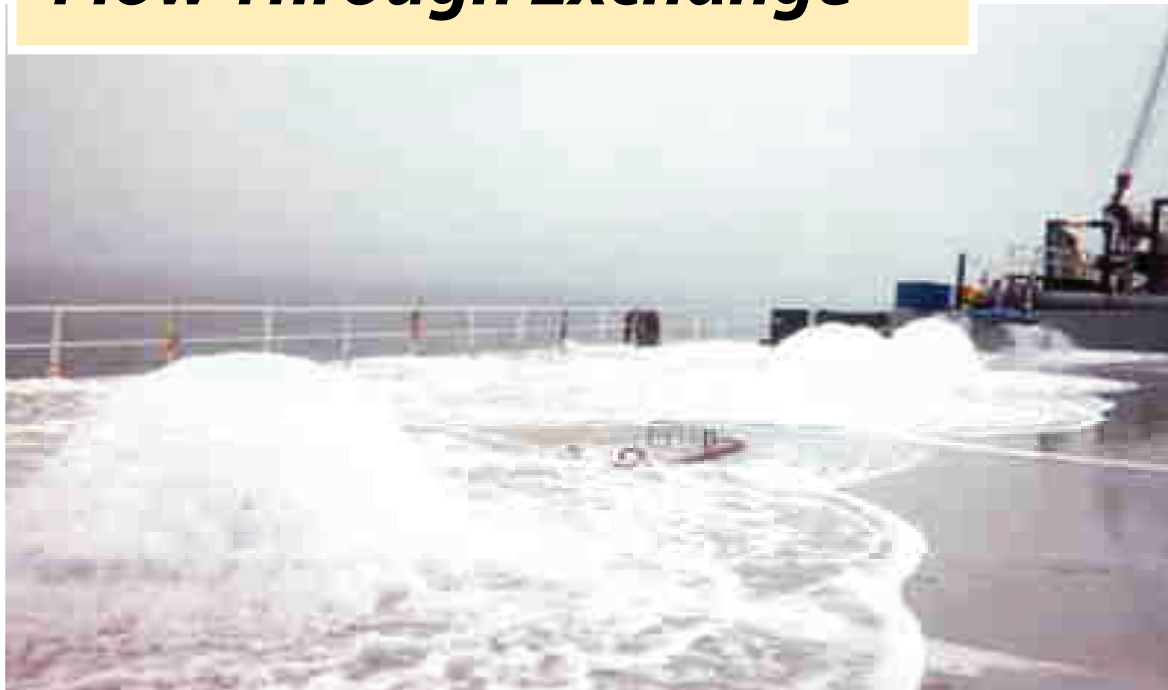
Ballast Water Management

Ballast Water Exchange in the open ocean is currently the most accepted method of treatment and will likely be for a considerable period of time for some vessels.

BW Exchange Procedure --- coastal water with its suite of organisms is removed from tanks and replaced by oceanic water between ports of call. The freshwater, estuarine and coastal organisms cannot survive the ocean environment and the oceanic organisms entrained in the process are unlikely to survive the freshwater, estuarine or coastal environments when discharged at port of arrival.

BW Exchange is not 100% Effective --- sediment may not be exchanged or tanks may be only partly emptied, allowing harmful species to remain in the tank. Most ships are not designed for safe and efficient BW exchange. The procedure cannot be safely performed in rough seas and in fact is not required if the master, operator, or person in charge determines that it will threaten the safety of the vessel or crew.

Flow Through Exchange



What to do?



EPA/ORD's ETV Program

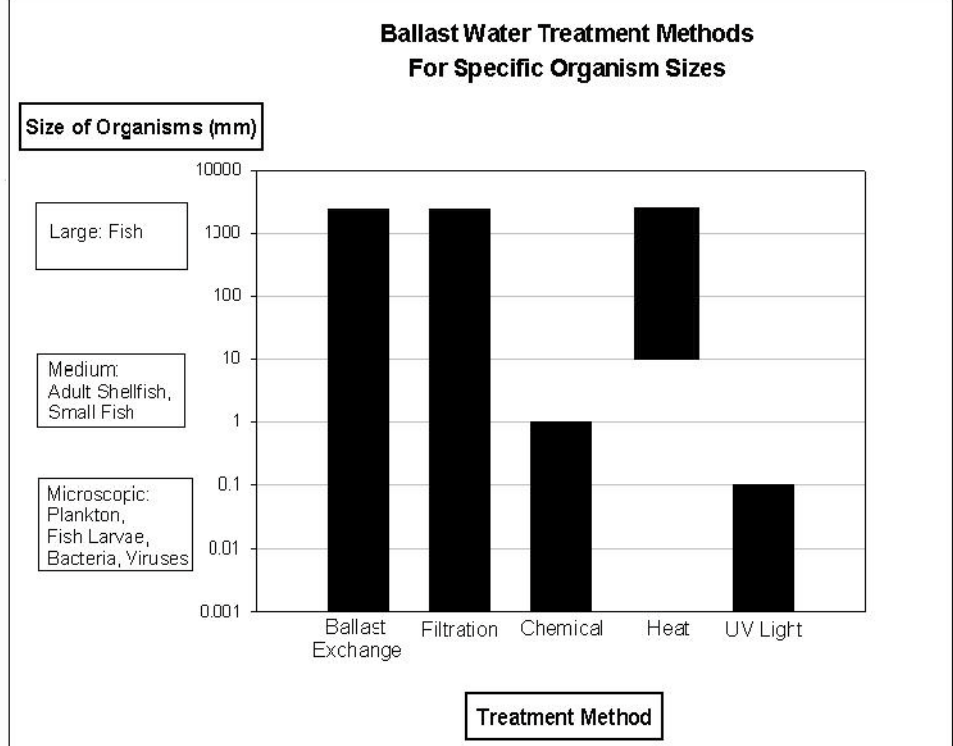
The ETV Program promotes the adoption of new environmental technologies in domestic and international markets. The Program operates through public/private testing partnerships to evaluate the performance of environmental technologies in all media. All protocols, test plans, and quality assurance plans are developed with the participation of technical experts, stakeholders, and vendors and are peer-reviewed prior to testing. The ETV Program is not an approval process, but a voluntary program intended as a service to stakeholders to verify the performance characteristics of commercial-ready environmental technologies through the evaluation of objective and quality-assured data, so that potential customers are provided with an independent and credible assessment of a technology. The verification of ballast water treatment technologies is one of several activities being conducted under the ETV's Water Quality Protection Center.



The goal of BWT is to eliminate organisms from BW as it is taken on board or discharged. No single technique has been able to remove all organisms/types of organisms. All possibilities require significant R&D to overcome the scaling factors associated with dealing effectively with the huge quantities of BW carried by large ships. In addition, treatment systems must not interfere with the safety and economical operation of the ship and must consider ship design limitations.

BWT technologies are defined as commercial-ready, prefabricated systems that can remove, kill or inactivate biological organisms

	Safety	Effectiveness	Commercial use				Cost		Size, complexity	Maintenance	Ease of monitoring
			Industrial	Marine	Power	Recirculation ¹	Plant	Crew size			
Oxidizing biocides halogen copper	+	+	+	+	+	+	+	+	+	+	+
Nonoxidizing biocides	+	+	+	+	+	+	+	+	+	+	+
Filtration systems media screen	+	++	+	+	+	+	+	+	+	+	+
Thermal treatment	+	+	+	+	+	+	+	+	+	+	+
Electric pulse and pulsed plasma techniques	+	+	+	+	+	+	+	+	+	+	+
Ultraviolet treatment	+	+	+	+	+	+	+	+	+	+	+
Acoustic systems	+	+	+	+	+	+	+	+	+	+	+
Magnetic fields	+	+	+	+	+	+	+	+	+	+	+
Deoxygenation	+	+	+	+	+	+	+	+	+	+	+



ETV BWT Verification Factors

Biological Performance - determination of the ability to remove/inactivate/destroy organisms... measured by removal efficiency (%) or a threshold (water quality standard) and the potential for survival/regrowth

Operation & Maintenance - measure of the operator time and skill required to achieve performance

Reliability - measure of the ability of the technology to perform over a period of time

Cost Factors - determination of the amount of chemicals, filter media or other consumables required to achieve performance, including power consumption & labor hours

Environmental Acceptability - evaluation of the compatibility of the technology with the receiving waters, particularly with regard to residuals of treatment chemicals or residuals produced by the treatment process

Safety - evaluation of potential chemical, electrical, mechanical or biological hazards associated with the operation/maintenance of the technology

Test parameters - salinity, total suspended solids (TSS), particulate organic material (POM), dissolved organic material (DOM), dissolved oxygen (DO), indigenous and surrogate species (bacteria, zooplankton, protist, phage, macro algae), O&M factors, turbidity (NTU), chlorophyll (Chl-a), adenosine triphosphate (ATP)

